CHAPTER 3

EXPERIMENTAL INVESTIGATION AND COLLECTION OF DATA

3.1 Description of site

The in situ testing and Soil Sampling involved in this research were carried out at two sites. Both are in Bangkok Metropolitan which is in the region of the Chao Praya delta in Thailand. The deposite in this region is known to be the recent marine clay namely Bangkok Clay. One site was at Memorial Bridge and the other was at Teves closed to the Bangkok Mass Transit alignment. The locations of these sites and bore hole locations are shown in Fig. 3.1, and Fig. 3.2 respectively. The distribution of pore pressure with depth was observed at the site of Memorial Bridge. At Teves site, the pore pressure data are not available. For the study in this thesis, it is decided to use pore pressure data from the observed station for Bangkok subsidence study at the Anan Throne, Parliament House, which is located about 0.50 Km. from the test site. The distribution of pore pressure at Memorial Bridge is shown in Fig. 3.3 and at the Anan Throne, Parliament House is shown in Fig. 3.4. These also include the computed values of total and effective overburden pressure.

3.2 Experimental Investigation and Collection of Data

3.2.1 Memorial Bridge site

3.2.1.1 Existing Data

The following data were collected from different sources as listed below (See Fig. 3.1 for locations)

Table 3.1 List of data collected from different sources at Memorial Bridge

Measurement	Depth (m)	Reported by
Field Vane test	2.00-17.00	THENCO report submitted to Norconsult-PAE-MEC Joint Venture
Dutch Cone test	0.00-21.00	THENCO report submitted to Norconsult-PAE-MEC Joint Venture
Unconfined Compression test	3.50-9.50	AIT report submitted to Norconsult-PAE-MEC Joint Venture
Anisotropically Consolidated Undrained Triaxial Compression test, Consolidated at in situ stresses	5.0 -9.50	AIT report submitted to Norconsult-PAE-MEC Joint Venture

3.2.1.2 Soil Exploration and Testing in this Thesis.

Soil exploration was carried out on undisturbed samples. They were sampling at 1.50 m. interval using 3" I.D. shelby tubes begining from 2.00 to 12.50 m. depth. Undisturbed samples were carried to laboratory and were push out to determine the following tests:- Water content, Atterberg limits, consolidated undrained direct shear tests, and consolidation tests at Chulalongkorn laboratory. Details of direct shear test are shown in Table 3.3

3.2.2 Teves site

3.1.2.1 Existing data

The following data were collected from different sources as listed below (See Fig. 3.2 for locations)

Table 3.2 List of data collected from different source at Teves

Measurement	Depth (m)	Reported by
Field Vane test	2.00-14.00	KEC
Unconfined Compression test	3.50-9.50	KEC
Anisotropically Consolidated Undrained Triaxial Compression Test, consolidated at in situ stresses	9.50-12.50	AIT report submitted to KEC

3.2.2.2 Soil Exploration and Testing in this Thesis

For this research soil sampling was done closed to the Bangkok Mass Transit alignment Undisturbed samples were taken at 1.50 m. interval using 3" I.D. shelby tubes begining from 2.00 to 12.50 m depth. The water content, Atterberg limits, Quick direct shear tests, consolidated undrained direct shear tests and consolidation tests were performed from these undisturbed samples at Chulalongkorn laboratory, Details of direct shear tests are shown in Table 3.3

Dutch cone test was also performed near the bore hole. The cone resistance and local friction values were observed.

3.3 Description of Procedure

3.3.1 Field Vane Test

Field vane tests were performed by KEC and THENCO with a

"Geonor" vane borer type. The assembly of the apparatus is as shown in Fig. 2.5, and the vane dimension is as follows:- 110 mm high with diameter of 55 mm. The assembly of the apparatus with the vane apparatus inside the protection shoe is pushed vertically down in to the ground, until 50 cm before the required depth is reached. Then, the vane is pushed out of the shoe 50 cm. further by applying force on the inner rod extending from the casing. The "Geonor" vane head which is used to provide the torque is then fastened tightly to the casing with the driving rod (inner rod) attached to the head. The torque was applied through this head and when the maximum torque used to shear the soil along the periphery of the vane occured, the degree of rotation was recorded. During the test rotation rate was kept at0.1 degree per second. The tests were performed at 50 cm interval in the soft clay deposit.

3.3.2 Dutch Cone Tests

A Dutch penetrometer of 10 tons capacity is used as a sounding apparatus in this study. The friction jacket cone had an apex angle of 60 degrees, and its diameter is 36 mm. Load is transferred to the point by metal rods. The prejected cross section area of cone is 10 cm^2, and the sleeve friction area is 150 cm^2. The first reading was encountered by the pressure guage when the cone tip was pushed down and the pressure reading plus the pressure due to the weight of the rods was recorded as cone resistance. The second reading is the combination of cone resistance and the local friction on friction sleeves. The cone penetrometer was advancing in to the soil, with the speed keeping constant at the rate of 2 cm/sec.

3.3.3 Soil Sampling

Unidsturbed samples were taken at 1.50 m. interval using 3" I.D. shelby tubes at the mentioned two sites. They were waxed on both sides of the shelby tube as soon as the samples reached the surface and then transported to laboratory.

3.3.4 Laboratory Tests

Undisturbed samples were carried to the laboratory and were pushed out from the sampling tubes. Water content, Atterberg limits, Consolidation tests, Consolidated undrained direct shear tests, and Quick direct shear tests were determined from the samples at each depth.

The consolidated undrained direct shear tests were carried out in Direct shear apparatus. The direct shear apparatus is shown in Fig. 3.5. Tests were conducted so as to measure the variation in undrained shear strength with depth. The soil specimen was prepared in the direct shear apparatus by trimming the specimen with triming device and it was push in to the moulded ring of 6 cm diameter and 4 cm thickness with a provided piston. The sample was trimmed again to fit the thickness of the moulded ring. Finally, the sample was pushed in to the sample ring with the same provided piston and it was ready to consolidate to the required pressure at $\bar{\sigma}_{vo}$. The process of pushing the samples in to the sample ring was rather difficult, and exercises should be taken in order to obtain the sample in the sample ring with a small degree of sample disturbance as much as possible. Filter papers and porous stones were provided at both top and bottom of the specimen when it was fixed in place. The normal stress was applied in the soil specimen step by step from 0.25 tsf (2.69 t/m^2) to the effective overburden pressure computed based on the known pore water pressure as presented. The next loading step would be twice the previous applied loading (e.e. $\frac{\Delta P}{P}$ = 1.0) and the soil was consolidated for 24 hours at each loading step. After the specimen was consolidated to its effective overburden pressure it was sheared at the rate of 0.1 mm/min.

For the unconsolidated undrained direct shear test, the normal stress in the sample was applied using the magnitude of the vertical effective overburden pressure, allowing no time for water pressure to dissipate, and then shear with no drainage. The shearing rate was kept at 0.1 mm/min. Table 3.3 lists the depths for testing, and the magnitudes of consolidation stress for quick and consolidated undrained direct shear test.

The consolidation tests were also carried out on the soil sample with depth. Table 3.4 shows details of the testing. The specimen was trimmed in the trimming apparatus and put in to the consolidation ring of 2.50 inches diameter and 1.0 inch thick. Filter papers and porous stone were provided both at top and bottom of the specimen, when it was fixed in place. A sample was consolidated using lever arm type. The consolidation apparatus is shown in Fig. 3.6. The initial consolidation pressure was set to be 0.25 tsf (2.69 t/m^2). The followed loading step will be twice of the provious step and the pressure was applied for a duration of 24 hours for each step.

Table 3.3 Detail of Direct Shear Tests

Depth (m)	Type of Direct shear test and Consolidation Stress	
	Memorial Bridge CU, $\bar{\sigma}_{vo}$ (t/m^2)	Teves CU and UU, $\bar{\sigma}_{vo}$ (t/m^2)
3.50	3.70	2.75
5.00	4.90	3.75
6.50	6.20	5.53
8.00	7.77	7.32
9.50	9.70	9.09
11.00	11.73	12.33
12.50	13.90	16.44

Table 3.4 Detail of Consolidation Tests

Depth (m)	Memorial Bridge		Teves	
	Stress increment (t/m^2)	Rebound Pressure (t/m^2)	Stress increment (t/m^2)	Rebound pressure (t/m^2)
3.50	0.85 to 15.5	7.6-2.9	2.69 to 172.60	172.60to21.52
5.00	0.97 to 31.1	15.5-5.7	-	-
6.50	1.25 to 92.0	15.5-3.8	2.69 to 172.60	172.60to21.52
8.00	-	-	-	-
9.50	1.90 to 92.0	31.0-7.6	2.69 to 172.60	172.60to21.52